

## CHAPTER 3

### SANITARY LANDFILL DESIGN

3-1. General. The designing of a sanitary landfill calls for developing a detailed description and plans that outline the steps to be taken to provide for the safe, efficient disposal of the quantities and types of solid wastes that are expected to be received. The designer outlines volume requirements, site improvements (clearing of the land, construction of roadways and buildings, fencing, utilities), and all the equipment necessary for day-to-day operations of the specific landfilling method involved. He also provides for controlling water pollution and the movement of decomposition gas.

3-2. Data for sanitary landfill planning.

a. Waste characteristics. The data on the solid waste for which disposal is required are: the types of waste, the amounts, and the variations in delivery rates. When possible, the information should be based on an analysis of solid wastes from the installation on which the project is located, or from a similar installation. For new installations, an analysis can be made based on the population to be served and other major sources of solid waste. The daily per capita quantity of solid waste for mobilization facilities will be 3 to 4 pounds of combined refuse and garbage. This rate is based on effective population which is the sum of the resident population plus one-third of the nonresident employees.

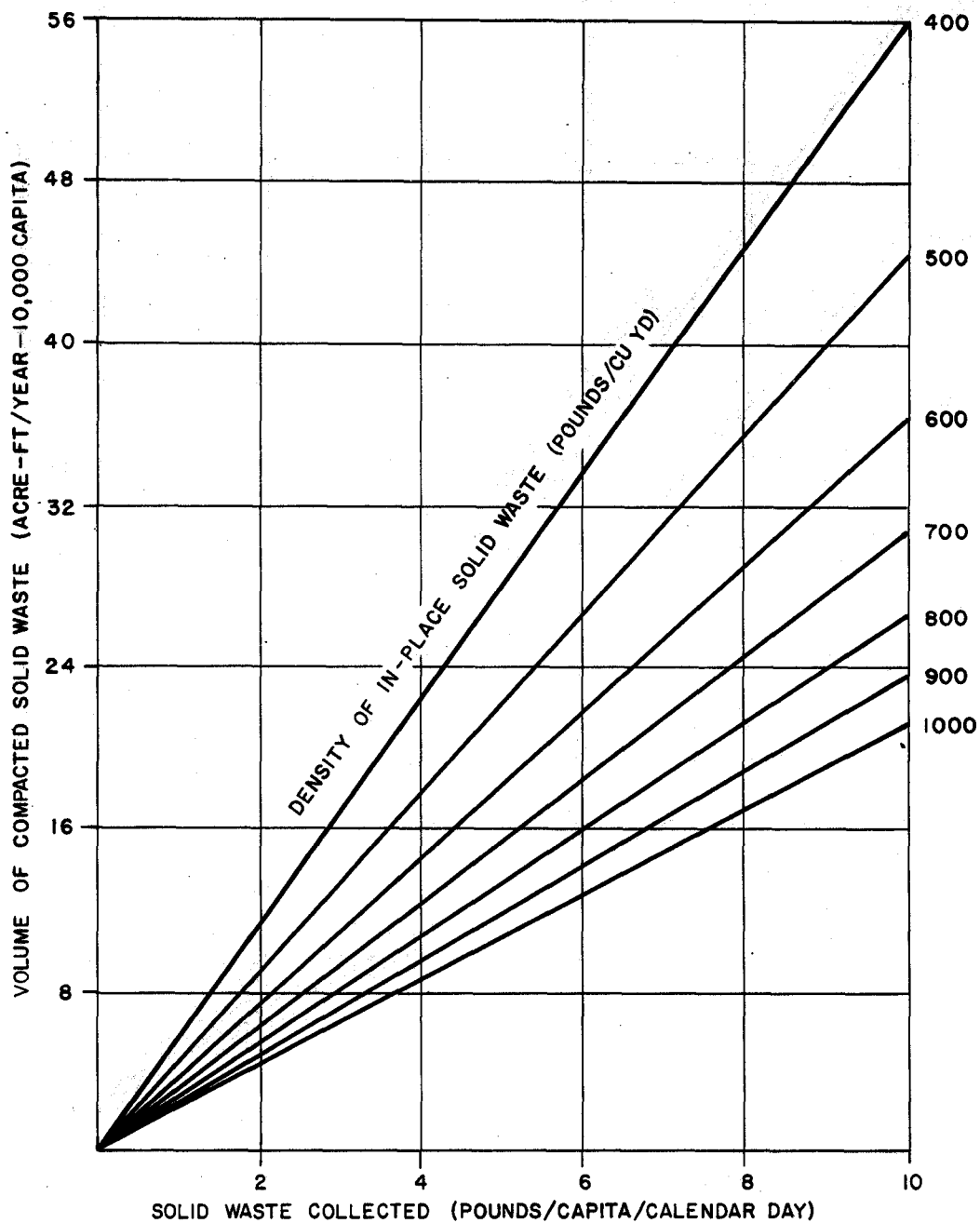
b. Operation equipment. Information on the equipment to be used, both for refuse delivery and sanitary landfill operation is required. This will include any planned changes in equipment. The capabilities of this equipment must be considered in evaluating factors such as access roads, grades, drainage, and operation in severe climates.

c. Operational methods. Methods of operating a landfill could have an effect on landfill design. Therefore, the desired method of operation should be reviewed before design commences.

3-3. Volume requirements. If the rate at which solid wastes are collected and the capacity of the proposed site are known, its useful life can be estimated.

a. Waste-to-cover ratio. The ratio of solid waste to cover material volume usually ranges between 4:1 and 3:1; it is, however, influenced by the thickness of the cover used and cell configuration. If cover material is not excavated from the fill site, this ratio may be compared with the volume of compacted soil waste and the capacity of a site determined from figure 3-1. For example, a facility having a 10,000 population and a per capita collection rate of 4 pounds per day must dispose of, in 1 year, approximately 16 acre-feet of solid waste

9 Apr 84



Environmental Protection Agency

FIGURE 3-1. YEARLY VOLUME OF COMPACTED SOLID WASTE FOR A FACILITY OF 10,000 PERSONS

9 Apr 84

if it is compacted to 600 pounds per cubic yard. If it were compacted to only 400 pounds per cubic yard, the volume disposed of in 1 year would occupy nearly 24 acre-feet. The volume of soil required for the 600-pound density at a solid waste-to-cover ratio of 4:1 would be 4.0 acre-feet; the 400-pound density waste would need 6.0 acre-feet. A density of 600 pounds per cubic yard will be used for mobilization design and operation.

b. Estimate of volume. The number of tons to be disposed of at a proposed sanitary landfill can be estimated by multiplying the effective population by the daily per capita quantity, then dividing by 2,000 pounds per ton. The daily volume of compacted solid waste can then be determined by using figure 3-2. The volume of soil required to cover each day's waste is then estimated by using the appropriate solid waste-to-cover ratio.

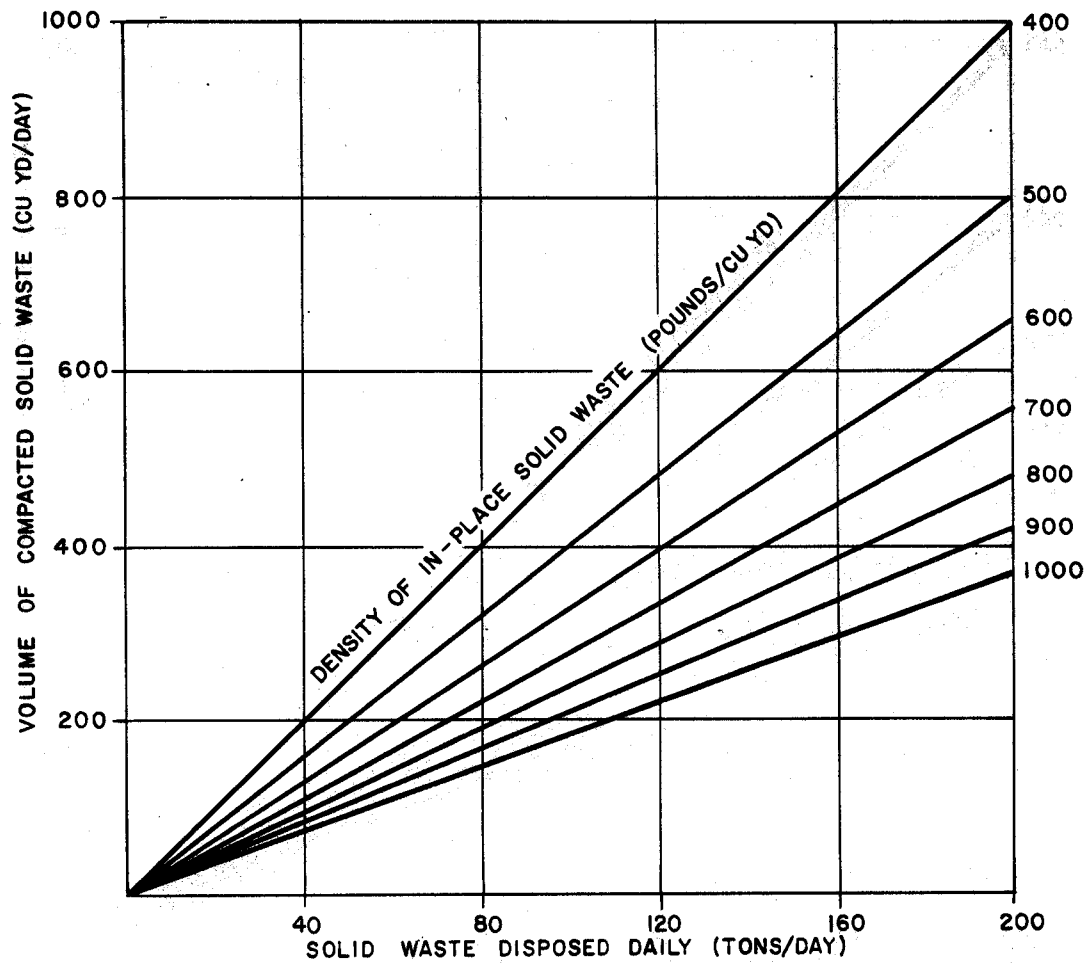
c. Densities. Solid waste density (field density) is the weight of a unit volume of solid waste in place. Landfill density is the weight of a unit volume of in-place solid waste divided by the volume of solid waste and its cover material. Both methods of reporting density are usually expressed as pounds per cubic yard, on an in-place weight basis, including moisture, at time of the test, unless otherwise stated.

3-4. Site improvements. The plan for a sanitary landfill should prescribe how the site will be improved to provide an orderly and sanitary operation. This may simply involve the clearing of shrubs, trees, and other obstacles that could hinder vehicle travel and landfilling operations or it could involve the construction of buildings, roads, and utilities.

a. Clearing and grubbing. Trees and brush that hinder landfill equipment or collection vehicles must be removed. Trees that cannot be pushed over should be cut as close as possible to the ground so that the stumps do not hinder compaction or obstruct vehicles. Brush and tall grass in working areas can be rolled over or grubbed. A large site should be cleared in increments to avoid erosion and scarring of the land.

b. Roads. Roads should be provided from the public road system to the site. A large site may have to have all-weather roads that lead from its entrance to the vicinity of the working area. They should be designed to support the anticipated volume of truck traffic. In general, the roadway should consist of two lanes (total minimum width, 24 feet), for two-way traffic. Grades should not exceed equipment limitations. For loaded vehicles, most uphill grades should be less than 7 percent and downhill grades less than 10. Temporary roads are normally used to deliver wastes to the working face from the permanent road system because the location of the working face is constantly changing. Temporary roads may be constructed by compacting the natural

9 Apr 84



Environmental Protection Agency

FIGURE 3-2. DAILY VOLUME OF COMPACTED SOLID WASTE

9 Apr 84

soil present and by controlling drainage or by topping them with a layer of a tractive material, such as gravel, crushed stone, cinders, broken concrete, mortar, or bricks. Lime, cement, or asphalt binders may make such roads more serviceable. If fewer than 25 round trips per day to the landfill are expected, a graded and compacted soil will usually suffice. More than 50 round trips per day generally justifies the use of calcium chloride as a dust inhibitor or such binder materials as soil cement or asphalt. A base course plus a binder is desirable if more than 100 to 150 round trips per day are anticipated.

c. Buildings. A building or construction-type field trailer should be provided for office space and employee facilities. Since a landfill operates in wet and cold weather, some protection from the elements should be provided. Operational records may also be kept at the site. Sanitary facilities should be provided for both landfill and collection personnel. Buildings should be temporary types and, preferably, be movable. The design and location of all structures should consider gas movement and differential settlement caused by the decomposing solid waste.

d. Utilities. All sanitary landfill sites should have electrical, water, and sanitary services. Remote sites may have to extend existing services or use acceptable substitutes. Portable chemical toilets can be used to avoid the high cost of extending sewer lines; potable water may be trucked in, and an electric generator may be used instead of having power lines run into the site. Water should be available for drinking, fire fighting, dust control, and employee sanitation. A sewer line may be called for, especially at large sites and those where leachate is collected and treated with domestic wastewater. Telephone or radio communications are also desirable.

e. Fencing. Peripheral and litter fences are commonly needed at sanitary landfills. The first type is used to control or limit access, keep out children and animals, screen the landfill, and delineate the property line. If vandalism and trespassing are to be discouraged, a 6-foot high fence topped with three strands of barbed wire projecting at a 45 degree angle is desirable. A wooden fence or a hedge may be used to screen the operation from view. Litter fences are used to control blowing paper in the immediate vicinity of the working face. As a general rule, trench operations require less litter fencing because the solid waste tends to be confined within the walls of the trench. At a very windy trench site, a 4-foot snow fence will usually suffice. Blowing paper is more of a problem in an area operation; 6-to 10-foot litter fences are often needed. Since the location of the working face shifts frequently, litter fences should be movable.

3-5. Control of surface water. Control of surface water runoff at a landfill disposal facility is necessary in order to minimize the potential for environmental damage to ground and surface waters by direct and indirect effects. Direct surface water contamination can

9 Apr 84

result from solid waste and other dissolved or suspended contaminants carried by surface runoff. Uncontrolled surface runoff can also contribute to leachate and gas generation, thereby increasing the potential for both surface and ground water contamination. Surface water courses should be diverted from the sanitary landfill and there should be no uncontrolled hydraulic connection between the landfill and standing or flowing surface water.

a. Seasonal variations. Quality, quantity, source, and seasonal variations of surface waters in the vicinity of the landfill disposal facility should be established to serve as a basis for design of any necessary surface water protection systems. Counseling and guidance in planning water management measures are available through local soil conservation districts upon request.

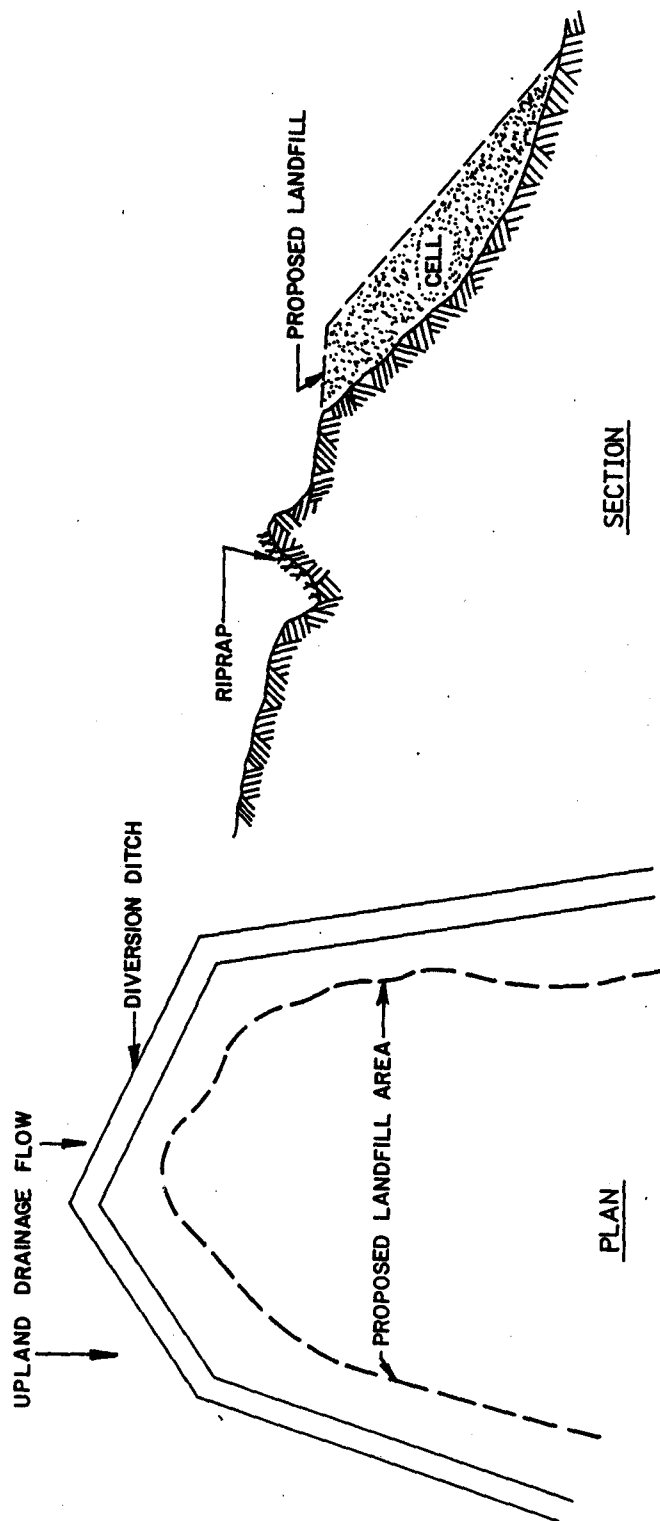
b. Piping and channels. Pipes may be used in gullies, ravines, and canyons that are being filled to transmit upland drainage through the site and open channels employed to divert runoff from surrounding areas (fig 3-3). Portable or permanent drainage channels may be constructed to intercept and remove runoff water. Low-cost, portable drainage channels can be made by bolting together half-sections of corrugated steel pipes. Surface water that runs off stockpiled cover material may contain suspended solids and should not be allowed to enter watercourses unless it has been ponded to remove settleable solids.

c. Sump pumps. Sump pumps may also be used. Because of operating and maintenance requirements, the use of mechanical equipment for water control is, however, strongly discouraged unless the control is needed only temporarily. If trenches or depressions are being filled, collection sumps and pumps may be used to keep them from flooding.

d. Flood plains. A dike with sufficient structural integrity should be constructed around any landfill disposal facility located within the 100-year floodplain of sufficient height to prevent inundation. Subsurface controls may also be necessary to prevent intrusion of water resulting from the temporary elevated ground water table during flooding. The top of the dike should be wide enough for maintenance work to be carried out and may be designed for use by collection and landfill vehicles.

e. Incident precipitation. Similar to surface runoff from surrounding areas, incident precipitation falling onto a landfill can result in two effects, namely, increased leachate generation and erosion of cover soil and solid waste. Techniques to carry incident precipitation from the landfill without causing erosion should be applied as follows:

(1) The final cover of the landfill should be graded such that water does not pool over the landfill. In order to minimize soil erosion, the final grade should not exceed 30 percent. Slopes longer



Environmental Protection Agency

FIGURE 3-3. PLAN AND SECTION VIEWS OF SURFACE WATER CONTROL

9 Apr 84

than 25 feet may require additional erosion control measures, such as construction of horizontal terraces, of sufficient width for equipment operation, for every 20 feet rise in elevation. Minimum slope, including terraces, should be 2 percent.

(2) The final soil cover on a completed landfill disposal facility should be seeded or otherwise vegetated to minimize erosion and maximize evapotranspiration.

(3) If landfill site design incorporates minimization of leachate generation, a low permeability cover soil with a low swell and shrink tendency upon wetting and drying should be utilized to avoid cracking.

### 3-6. Ground water protection.

a. Ground water uses. Current and projected use of ground water resources in the vicinity of the landfill disposal facility should be determined as a basis for design of any necessary ground water protection system as follows:

(1) Establish initial (background) quality of water resources in the potential zone of influence. If ground water analyses determine that the total dissolved solids (TDS) content of the water is greater than 10,000 mg/l, then it shall be termed unusable and no protection of the ground water will be required.

(2) Establish the depth to the water table and the direction and rate of ground water flow with consideration of withdrawal rates by ground water users.

(3) Establish potential interactions of the landfill disposal facility, its hydrogeology, and the real ground and surface waters, based upon historical records and other sources of information.

b. Leachate control measures. Landfill leachate generation cannot be avoided except in some arid climates; therefore, leachate control measures for water quality protection should be incorporated in the site design when the ground water has been determined to be usable. Leachate control, when necessary with site design, should be accomplished through application of one or more of the following practices:

(1) Unless underlying ground water is determined to be unusable as a drinking water or other supply source and therefore not in need of protection, the bottom of a landfill disposal facility should be substantially (5 feet or more) above the seasonal high ground water table, to prevent direct contact of disposed solid waste and the ground water.



9 Apr 84

(2) A liner may be employed to control the movement of fluids, and many types of material can function successfully in this capacity. The rate of passage of leachate through liner materials is a function of the measured permeability of the material and the depth (or head) of leachate on the liner. In general, the rate of flow increases with depth of leachate.

(a) The variety of liner materials available include naturally occurring materials such as clays, amended natural materials such as soil cements, and artificial materials such as asphaltic materials and polymeric membranes.

(b) Liner materials which are to significantly restrict the flow of leachate from the bottom of the landfill should have the following properties.

- Permeability of  $1 \times 10^{-7}$  cm/second (about 0.1 foot/year) or less.
- Ability to resist physical and chemical attack by leachate.
- Capability of maintaining integrity for the design life.
- The practical minimum thickness for natural soil liners is 12 inches.
- The practical minimum thickness for synthetic membrane liners is 20 mils.

(c) Artificial liner material, if selected, should be placed upon a carefully prepared base of selected material which will prevent liner puncture while providing uniform support and should be covered with suitable material that will further protect the liner from damage and provide a drainage blanket for the leachate collection system. Approximately 2 feet of material is effective in protecting a liner from mechanical damage (puncture). The lowest 6 inches of material should be highly permeable to allow the leachate collection system to function properly.

(d) Removal of leachate collected on a liner should be incorporated into the design of a lined landfill to avoid surface seepage and relieve hydraulic pressure on the liner. To facilitate leachate removal, liner materials should be sloped to one or more points and covered with a layer of highly permeable material such as pea gravel. A grade of 1 percent or more should be utilized.

(e) Once collected, landfill leachate should be disposed to the land or surface water in an environmentally sound manner to protect surface and ground water quality. (Public Law 92-500 requires a permit for the discharge of collected leachate to surface water.)

9 Apr 84

- Leachate treatment and disposal should consist, as a minimum, of a lined waste stabilization pond with controlled discharge.
- Raw or treated landfill leachate should be discharged into a municipal or industrial wastewater treatment system only if this discharge will not impede the operation of the wastewater treatment system. Limited experience has shown that when raw municipal solid waste leachate volume exceeds about 5 percent of the total wastewater treatment plant flow, interruption of biological treatment processes may occur.
- Raw or treated leachate can be disposed by controlled application onto the surface of the land provided sufficient acreage is available and hydrology, soil type, vegetation, topography, and climate for leachate disposal have been considered, and surface or ground water contamination will not occur.
- Recirculation of collected landfill leachate onto active or completed sections of the landfill can reduce leachate constituent concentrations by chemical and biological processes and may be effective in reducing leachate volume. This technique can result in, at least, partial stabilization of young (0 to 5 years) landfill leachates which are relatively concentrated in comparison with rather old stabilized landfill leachates.

3-7. Gas control. Control of gases from a landfill disposal facility may be accomplished by techniques which: minimize the production of decomposition gases or occurrence of other harmful gases, control the escape of gases into the atmosphere, and minimize the migration of gases into soils surrounding the site. Gas control should be accomplished in accordance with the following:

- a. Minimize infiltration. Leachate and runoff control measures which are intended to minimize the infiltration of water into a solid waste landfill may also reduce gas generation, primarily  $\text{CH}_4$  and  $\text{CO}_2$  resulting from decomposition of disposed organic solid waste.
- b. Prohibit volatile substances. Volatile solid waste materials or wastes with a known high potential for release of harmful gases as a result of chemical reaction should not be accepted for disposal at a landfill disposal facility where such gases are normally required to be minimized or avoided.
- c. Encapsulate the solid waste. Encapsulation of solid waste in a landfill (e.g., low permeability liner and final cover) to prevent or minimize infiltrating water should be coupled with an effective

9 Apr 84

ventilation system to remove decomposition gas from the landfill, as necessary.

d. Allow vertical migration of gases. If a relatively porous material is used for cover at a landfill, which does not impede infiltrating water, gases should migrate vertically out of the landfill surface, except when frozen or saturated, for dissipation into the atmosphere. However, deep landfills may experience gas pressure buildup, regardless of cover used.

e. Review surrounding land area. Since horizontal migration of gases from landfills (due to both diffusion and pressure gradients) through surrounding soils is common, a review of the land area surrounding the landfill proper should be performed. For shallow landfills, a "rule of thumb" for estimating potential gas migration is a distance equal to 10 times the maximum depth of the landfill below original grade. If nearby underground utilities exist, additional reviews along the utility corridor should be performed.

f. Passive barriers. Passive barriers which may be considered for the prevention of horizontal migration of gases include:

(1) Cutoff walls constructed of naturally occurring materials, such as compacted moist clays, or artificial materials, such as asphaltic or polymeric materials.

(a) To assure effectiveness, the cutoff wall should extend from the ground surface down to a gas impervious layer (e.g., bedrock or ground water) below the bottom of the landfill.

(b) Even though polymeric materials may be virtually impermeable to water, they should be evaluated for permeability to gases.

(c) Even when compacted, clays and other soils are impermeable to gases only when water saturated.

(2) Venting systems, installed either on or off the landfill proper, consist of either gravel-filled trenches, perforated pipes, or both.

(a) Perforated pipes have been shown to be of limited effectiveness except in the immediate vicinity of the pipe and are therefore not recommended for reduction of pressure in a landfill, when used alone.

(b) Gravel-filled trenches, while generally more effective than perforated pipes, still permit some migration of gases across the trench, especially when covered by snow or ice.

9 Apr 84

(c) Gravel-filled trenches equipped with vertical perforated pipes have been shown to reduce the effect of temporary covers such as ice or snow but remain of limited effectiveness in landfill gas migration control.

(d) Gravel-filled trenches must usually be equipped for removal of water or leachate from the trench bottom and are susceptible to plugging by biomass buildup.

(3) Combination passive barriers installed off the landfill, which consist of gravel-filled trenches in combination with an impermeable barrier installed on the side of the trench opposite the landfill, provide good protection against horizontal gas migration when keyed to a gas impermeable strata below the landfill.

3-8. Plans for design, construction, operations, and maintenance of sites. Plans for design, construction, operations, and maintenance of sites should include:

a. Evidence. Evidence of compliance with applicable state and Federal regulations.

b. Detailing. Careful detailing of all design and operational considerations necessary to bring site conditions to an acceptable level.

c. Presentation and discussion. A clear presentation and discussion of any separate areas which have been incorporated into the landfill design for disposal of specific wastes requiring special or separate handling.

d. Other. Other pertinent information, such as:

(1) Initial and final topographies at contour intervals of 5 feet or less as specified by the state and local regulatory authorities.

(2) Land use and zoning within, at least, one-quarter mile of the site showing the location of all private wells, water courses, rock outcroppings, roads, and buildings.

(3) Location of all airports within 2 miles of the site.

(4) Location of all utilities within, at least, 500 feet of the site.

(5) Temporary and permanent all-weather access roads.

(6) Screening and other nuisance control measures.

9 Apr 84

(7) Narrative descriptions, with associated technical drawings, indicating site development and operation procedures.

(8) Contingency plans.

3-9. Cover material. The cover material selected should provide for a balance among the major functions of:

- Vehicle traffic.
- Water infiltration control.
- Gas migration control.
- Fire resistance.
- Erosion control.
- Vector control.
- Support of vegetation.